PROPULSION DIRECTORATE

Monthly Accomplishment Report
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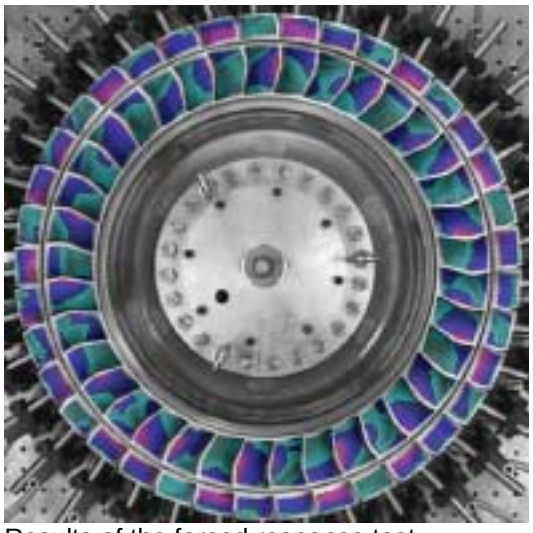
FAN STAGE VIBRATIONS EXAMINED THROUGH TEFF TESTING: During an initial demonstrator engine test, three high response resonant modes were encountered on the Core Driven Fan Stage (CDFS) of the XTC 76/3 manufactured by the team of General Electric and Allison Advanced Development Company. Due to the unique design and construction of this engine component, current predictive analysis methodologies could not be used to validate the proposed modification to alleviate the high vibrations. Therefore, the Propulsion Directorate offered to investigate the phenomena experimentally. The Traveling Wave Excitation system of PR's Turbine Engine Fatigue Facility (TEFF) was used. Previous to the CDFS test, the Traveling Wave Excitation System had only been used for basic research on less complex structures. A major redesign and expansion of the system's capability was initiated and completed in less than six weeks. The excitation system electronic circuitry was redesigned to expand from 18 to 37 channels and the mounting of the laser scanning vibrometer was modified to achieve full coverage of the XTC 76/3's 40-inch blisk. Hard work, good planning, and exceptional teamwork by all involved ensured that modifications were completed by the time the blisk was delivered. All experiments were performed and the desired data obtained on schedule, allowing the blisk to be returned to the contractor without causing additional delay to the demonstrator schedule. By completing this excitation experiment in a timely fashion, the test schedule for this Integrated High Performance Turbine Engine Technology (IHPTET) demonstrator engine was maintained. Keeping the test on schedule is critical to reaching IHPTET Phase III goals which rely heavily on the Phase II technologies being demonstrated. Furthermore,

The In-House Project of the Quarter Team (from L to R): Dr. Charles Cross, Capt Keith Jones, Mr. Gary Terborg, and Mr. Michael Barga (not pictured, Mr. Steve Fuchs).

Experimental setup showing excitation of fan blades using acoustic techniques



Results of the forced response test highlighting blade deflection patterns

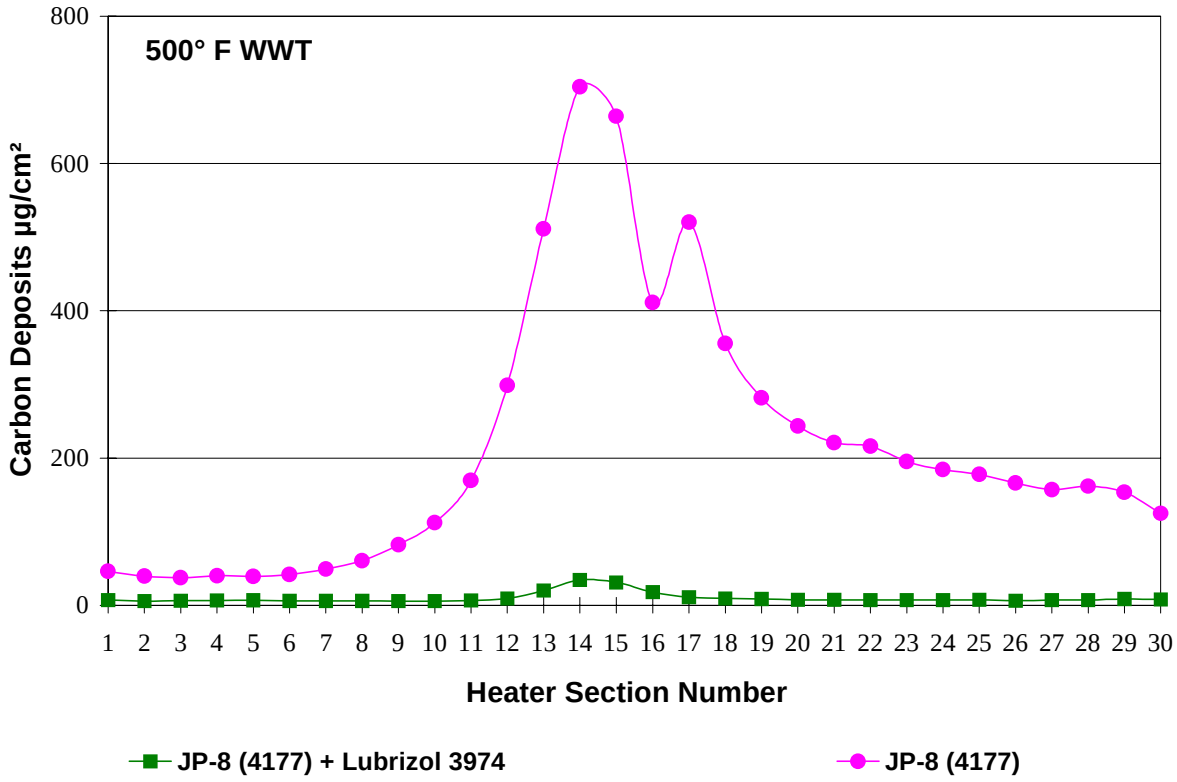
the data obtained alleviated a critical uncertainty that could have led to a very costly blade failure during the engine test. This effort, under the title "Engine Order Excitation of XTC 76/3 Core Driven Fan Stage," was named PR's In-House Project of the Quarter for the 3rd Quarter of 2002. Dr. Charles Cross, Mr. Michael Barga, Mr. Gary Terborg, and Capt Keith Jones of PRT and Mr. Steve Fuchs of the University of Dayton Research Institute (UDRI) were honored as part of the award winning team. (C. Cross, AFRL/PRTC, (937) 656-5530)

ROQUEMORE SELECTED AS ASME FELLOW: The Propulsion Directorate's Dr. W. Melvyn Roquemore was recently selected as a Fellow in the American Society of Mechanical Engineers (ASME). The ASME Fellow Grade recognizes significant engineering achievements and contributions to the engineering profession. Dr. Roquemore joined the Air Force Aero Propulsion Laboratory (now the Propulsion Directorate) in 1963 and embarked on a 40-year career of scientific achievement. He has distinguished himself as an Air Force laboratory technical manager in fundamental and applied combustion research and development. Not only does he possess a tremendous grasp of the technology, but he has an intense enthusiasm for the work and an exceptional ability to form national and international teams. His particular expertise lies in the areas of advanced laser-based combustion diagnostic techniques, combustion models, experiments on combustion fundamentals, and advanced propulsion concepts. Among his most recent successes is an innovative combustor concept known as the Trapped Vortex Combustor (TVC). The TVC is a major departure from the conventional swirl-stabilized combustors used for the past 40 years in gas turbine engines. The TVC is a low-emission, high-performance combustor that has the potential to revolutionize the future of military and civilian gas turbine engine combustors. Over his illustrious career, Dr. Roquemore has produced 167 technical papers and is the holder of four patents. His expertise is recognized worldwide, and he is often invited to lecture at universities and professional organizations. In addition to this honor, Dr. Roquemore is a Fellow in the American Institute for Aeronautics and Astronautics (AIAA), a Fellow of the Wright Research and Development Center (now AFRL), a three-time winner of PR's Heron Award, and a two-time recipient of the AFOSR Star Team Award. (R. Hancock, AFRL/PRTS, (937) 255-6814)


Dr. W. Melvyn Roquemore

NEW +100 ADDITIVE PASSES THE TEST: The Propulsion Directorate's Fuels Branch (AFRL/PRTG) recently announced that a second formulation for the +100 Thermal Stability Fuel Additive successfully completed thermal stability testing. The +100 additive was developed under a PRTG program in an effort to minimize maintenance associated with fuel degradation in

aircraft engines and fuel systems. The fielding of the original +100 additive has been a major success, as it has significantly reduced fuel-related maintenance costs for a wide range of military and commercial systems. The addition of a second source for the additive is an important step, as it creates competition that should reduce the cost of the additive to the Air Force. Previously, the only approved +100 additive was manufactured by BetzDearborn, but a new formulation developed by the team of BP/Lubrizol has successfully completed the rigorous thermal stability test regimen laid out by PRTG. In a meeting held on 3 October 2002, a number of parties with a keen interest in this additive technology gathered to review the results of the testing of the BP/Lubrizol additive. These parties included representatives of PR; the Materials & Manufacturing Directorate (AFRL/ML); the University of Dayton Research Institute (UDRI); and major engine manufacturers, General Electric (GE), Pratt & Whitney, and Rolls Royce. In order to gain PRTG approval, an additive must pass a series of five in-house tests, and presentations made at this meeting verified that the BP/Lubrizol additive had successfully completed the required testing. In addition, GE presented results of preliminary hot section materials compatibility testing which showed that the BP/Lubrizol additive had successfully passed these tests as well. As a result of this meeting, the engine manufacturers and AFRL/ML bought into a cooperative process to proceed with the fielding of the additive. Furthermore, the Canadian military has volunteered to provide some of their engine test facilities to test the new BP/Lubrizol additive in conjunction with their conversion of ground based aircraft to NATO F-37 (aka JP-8+100) fuel. (P. Pearce, AFRL/PRTG, (937) 255-6918)



Plot showing reduction in carbon deposits with the use of the BP/Lubrizol additive

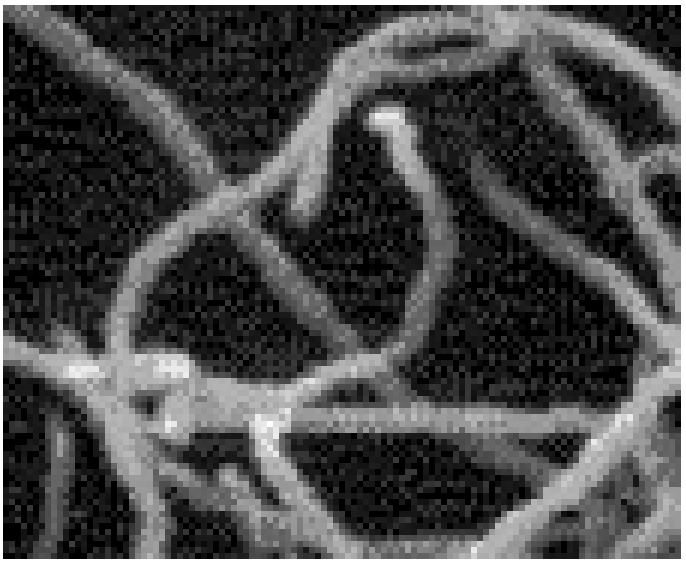
1440 channels of signal conditioning

Calibration unit

IMPROVED COMPRESSOR RESEARCH FACILITY READY TO MEET IHPTET AND VAATE GOALS: A new state-of-the-art High Performance Data Acquisition System (HPDAS) has been successfully integrated into the Propulsion Directorate's Compressor Research Facility (CRF). To meet the demands of the Integrated High Performance Turbine Engine Technology (IHPTET) Program and expected requirements of the Versatile Affordable Advanced Turbine Engines (VAATE) technology program, the new system provides a 76% increase in measurement capability over the original 25-year old system. The new data acquisition system allows direct connection of the sensors to the signal conditioners, eliminating the need for patch panels. This reduces set up time and improves accuracy and reliability in comparison to the old system. The footprint of the new system is only 10% that of the old system making 327 square feet available for special test equipment anticipated for future CRF testing. The old system was nearing the end of its life cycle and required an inordinate amount of maintenance. The new system reduces the maintenance burden by $250K/year which will result in a payback of the new system's cost in only three years. Previously, each channel was calibrated with a dedicated standard which in turn was calibrated against a NIST traceable standard. The intermediate calibration step, and the associated loss in accuracy as a result of that step, were eliminated by calibrating all channels directly with one NIST traceable standard. Final checkout of the system was accomplished at the beginning of the XTE-67 test program in August 2002. The new system has exhibited a consistent 100% availability while the failure rate of the older system was 2-3%. The new system will now be used to effectively and accurately evaluate the advanced technology being developed under the IHPTET and VAATE National Turbine Engine Technology programs. (D. Chaboty, AFRL/PRTE, (937) 255-6802, x406)

FERNANDEZ RECOGNIZED FOR CONTRIBUTIONS TO INSULATION PROGRAM: Ms. Marietta B. Fernandez was named the Propulsion Directorate's Employee of the Month (Staff Support/Technician Category) for August 2002. Ms. Fernandez was recognized for her dedicated and timely efforts to provide scanning electron microscope (SEM) images for an advanced insulation program. It was critical that these images be provided in a short time, because they were needed for research being performed by a visiting professor. Due to her timely efforts, a 4-month delay in the program was prevented. The high quality SEM images that Ms. Fernandez obtained were critical in showing how the structural reinforcement of a new additive called Vapor Grown Carbon Fiber (VGCF) results in substantial improvements in ablation

Ms. Marietta B. Fernandez



Sample SEM image

resistance. This technology has the potential to improve ablation resistance by at least a factor of two. Furthermore, the insulation is relatively straightforward to process into existing systems and is lower in cost, so the payoffs are substantial. In fact, the combination of VGCF with POSS (polyhedral oligomeric silsesquioxanes) nanotechnology could represent the most revolutionary advancement in solid rocket motor insulation in 30 years. It is noteworthy that Ms Fernandez's efforts to provide these critical SEM images were in addition to her normal duties. The images she obtained were presented to the solid rocket motor community at the POSS Nanostructured Chemicals Workshop held in Huntington Beach, California, from 25-27 September 2002. (S. Phillips, AFRL/PRSM, (661) 275-6270)

PROGRESS TOWARDS NEW HIGH TEMPERATURE FUEL: The Propulsion Directorate's Fuels Branch (AFRL/PRTG) recently demonstrated technologies that may lead to the next generation high temperature fuel. At the outset of the program to develop JP-8+100, the goal was to raise the usable fuel temperature by 100°F. However, as new engine designs place greater demands on the fuel, the need for an even higher temperature fuel has surfaced. This fuel has been dubbed +225 because the goal is to increase the usable temperature of JP-8 by 225°F from 325°F to 550°F. PRTG is pursuing +225 under the High Heat Sink Fuels (HHSF) Program. The current technologies being considered for +225 consist of a combination of (1) a thermal stability fuel additive, (2) deoxygenation of the fuel, and (3) coatings. Testing was recently performed on PRTG's in-house Phoenix Rig to assess the feasibility of these technologies. Three separate runs

Phoenix Rig

were made, one with standard JP-8, one with JP-7, and one with JP-8 incorporating all three +225 technology candidates. Phoenix Rig testing at +225 conditions of the standard JP-8 fuel had to be terminated after 71 hours due to coking, but testing of JP-8 incorporating the +225 technologies and JP-7 both met the goal of 200 hours of operation at +225 conditions. These results demonstrate the feasibility of using these technologies to achieve the goals of the +225 program. Note that JP-7 fuel already meets the +225 goals, but its cost is prohibitive. Efforts will continue under the HHSF Program to mature additive, deoxygenation, and coating technologies for use in +225 and even higher temperature fuels such as JP-900, which is to operate at 900°F. (P. Pearce, AFRL/PRTG, (937) 255-6918)

INTELLIGENT CONTROLS FACILITY BASELINE CAPABILITY DEMONSTRATION: On 30 September 2002, the Propulsion Directorate's newly-created Intelligent Controls Facility (ICF) held a demonstration of its baseline capabilities. The ICF was established within the Engine Integration and Assessment Branch (AFRL/PRTA) with a dual mission. First, the ICF is tasked to define, implement, and document a component-based modeling capability, including simulating the operation of a modern, gas turbine propulsion system in real time. Second, the facility will provide capability to test turbine engine-related auxiliary components such as servo-actuators, advanced fuel valves, and engine control units. The recent capability demonstration showcased both the engine simulation capability and the component test capability. The engine model demonstrated was a two-spool turbofan, non-augmented and with mixed flow through a single nozzle. This was a generic engine loosely based on the AE3007 engine. The model was prepared by Dr. Zane Gastineau, with continued development by SMI, using generic performance cycle deck data provided by PRTA. This engine model was controlled using a simple control model having an external throttle controlling the fan speed setting. The hardware test featured an experimental high response fuel valve designed and fabricated by SMI under a separate contract. This test demonstration illustrated the use of the RCP rack to provide test outputs to the test hardware and data acquisition and display. Future plans for the ICF include the continuing development of the generic component-based model for general use by PRTA and other associated government, commercial, and academic organizations. Also planned is expansion of the HIL rack to include multi-processor operation, inclusion of interface busses (MIL 1553, ARINC 429, etc.) with the RCP rack, further development of signal interface boxes, interface testing of the GE/BAE systems Flexible FADEC, and the continued definition and

Engine model running on dSpace system

Testing of high response fuel valve

development of advanced engine life extension control systems and health management models with further expansion of the demonstrated component testing capabilities. (D. Tasch, AFRL/PRTA, (937) 255-6690)

CHU NAMED EMPLOYEE OF THE MONTH: Mr. Thanh V. Chu was named the Propulsion Directorate's Employee of the Month (Scientist/Engineer Category) for September 2002. Mr. Chu was honored for his outstanding efforts to prepare PR's facilities for the recent Unit Compliance Inspection (UCI). He ably performed these tasks while simultaneously performing all of his normally assigned duties. His keen engineering knowledge, professionalism, and leadership skills were instrumental in the achievement of an "In Compliance" rating for all five safety areas that were inspected. These five areas were Ground Safety, Systems Safety, Confined Spaces, Foreign Object Damage (FOD), and Fabrication/Shop Equipment. Mr. Chu drafted PR's first instruction for the FOD Program, publicized the program, and implemented awareness and prevention training. He also developed safety checklists that served as a valuable aid in the critical pre-UCI review of all research facilities. Furthermore, he prepared briefings and provided training on lockout/tagout procedures, HazMat, and overhead cranes and hoists to assure that directorate personnel were up to speed in these areas. Due to the transfer of the Ground Safety Technician, Mr. Chu took on these duties and performed them in an exemplary manner. This included performing corrective actions on safety reports along with tracking, reviewing, and following-up on monthly laboratory safety inspection reports. Due to these many accomplishments, Mr. Chu is a worthy recipient of this honor. (C. Kessler, AFRL/PROE, (937) 255-4210)


Mr. Thanh V. Chu